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ABSTRACT

The purpose of this study was to determine: (1) the effects of repeating words in compound sentences; and (2) the differences in encoding processes in short term memory for natural language materials compared with nonlinguistic material. A series of give experiments was administered to first graders, college students, and older subjects. The findings point to a general short term memory encoding strategy for compound sentences and digits, letter and word strings with compound structures. (Author/EK)

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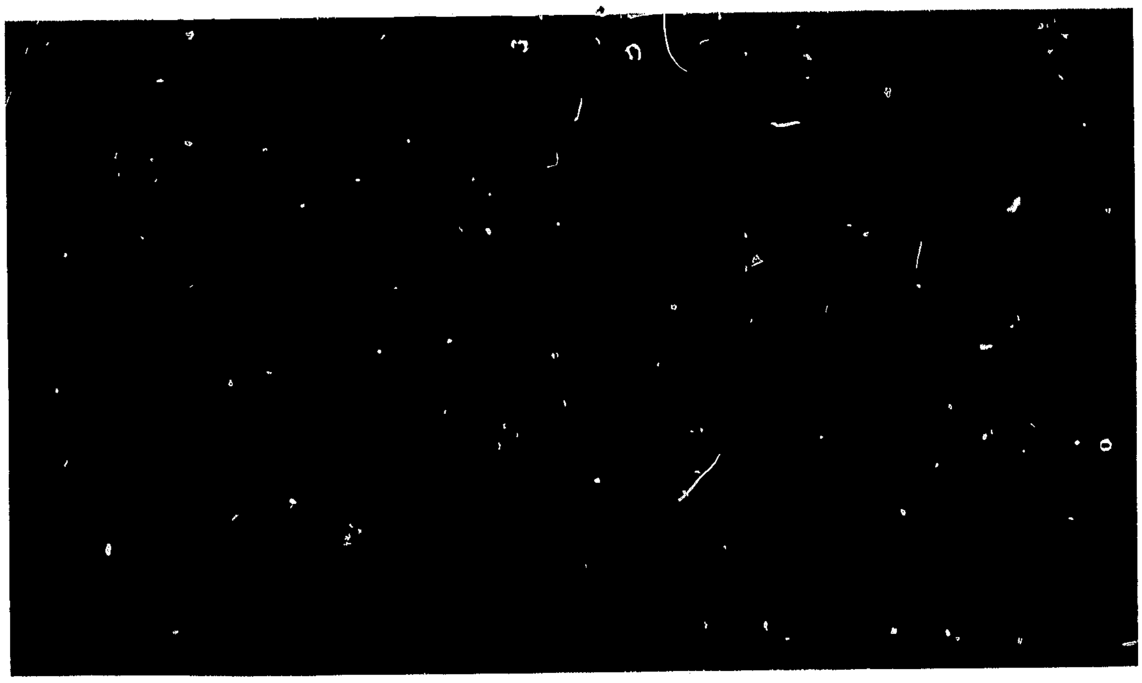
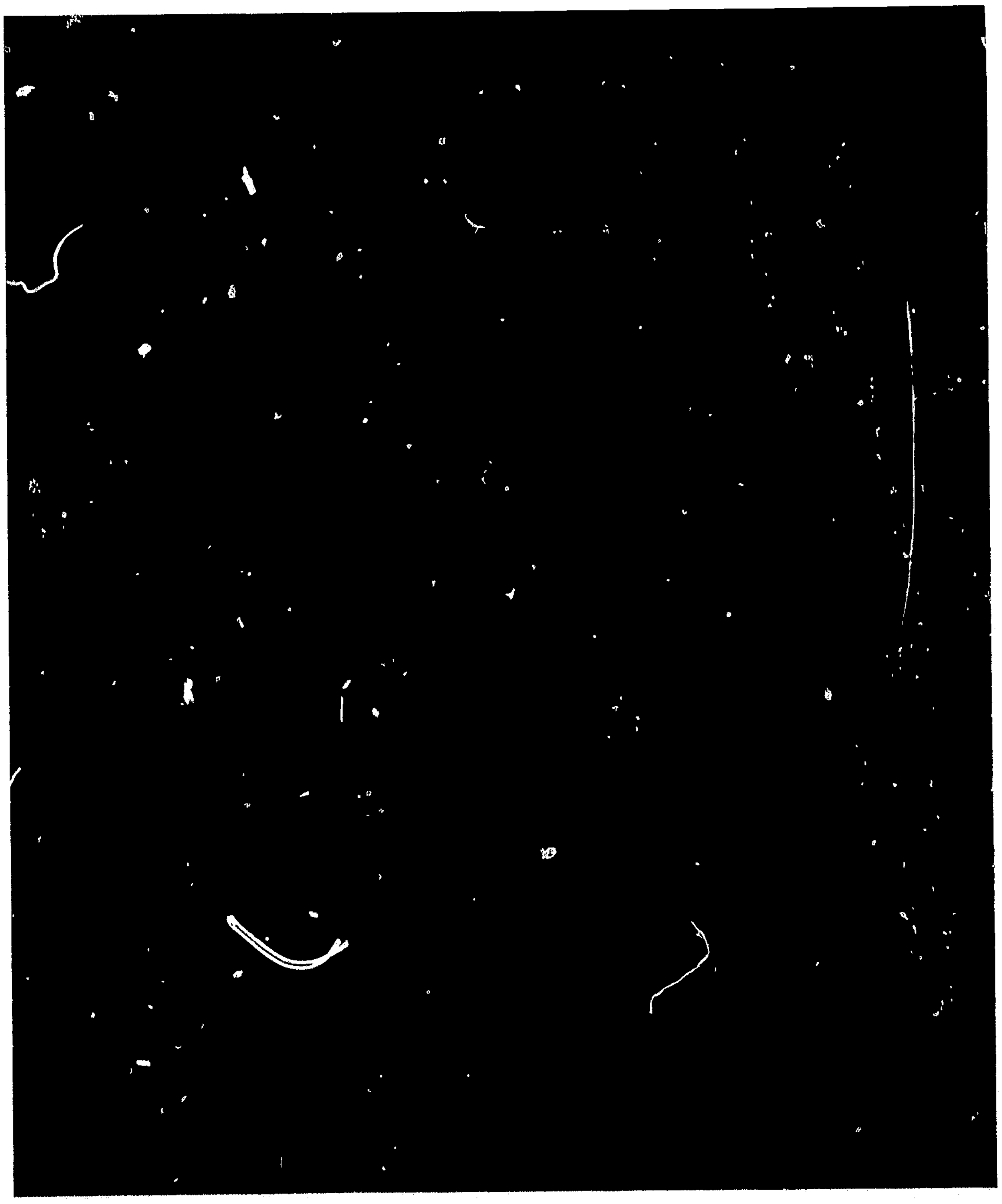


MEMORY FOR PARALLEL STRUCTURE AND REPEATED ITEMS IN COMPOUND SENTENCES AND DIGIT, LETTER, AND WORD STRINGS

Report from the Project on Language Concepts and Cognitive Skills Related to the Acquisition of Literacy



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MEMORY FOR PARALLEL STRUCTURE AND REPEATED ITEMS IN COMPOUND SENTENCES AND DIGIT, LETTER, AND WORD STRINGS

Report from the Project on Language Concepts and Cognitive Skills Related to the Acquisition of Literacy

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Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin
March 1970

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STATEMENT OF FOCUS

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Language Concepts and Cognitive Skills Related to the Acquisition of Literacy Project in Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and to develop educational materials suggested by prior activities. Contributing to these Program objectives, this project's basic goal is to determine the process by which children aged four to seven learn to read, examining the development of related cognitive and language skills, and to identify the specific reasons why many children fail to learn to read. Later studies will be conducted to find experimental techniques and tests for optimizing the acquisition of skills needed for learning to read. By-products of this research program include methodological innovations in testing paradigms and measurement procedures; the present study is an example.

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Mrs. Sharon Volovsek deserves special mention. Without her excellent work in preparing the manuscript, deadlines could never have been met. The staff of the R & D Center have provided many essential services to make the conduct of the research and preparation of this report possible. The cooperation of the faculty and staff of Sherman Elementary School in Madison, was invaluable during the testing of the first grade <u>S</u>s.

To the U. S. Office of Education I owe a special debt. The funds for this research, as well as the past two years of my education, were provided by the Office of Education.

Finally, Jobo and the regulars at the Harmony House provided much needed relaxation at intervals during the writing of this paper.

CONTENTS

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Abstract

Five experiments were conducted to answer two major questions with regard to short-term memory for sentences: First, what are the effects of repeating words in compound sentences? Second, what are the differences in encoding processes in short-term memory for natural language materials compared with non-linguistic material?

Experiment I demonstrated the generality of earlier work which showed that immediate recall for compound sentences was a function of the number of words repeated between the clauses of a compound sentence. An index, defined as the proportion of repeated words between clauses, was linearly related to total number of words recalled. Experiment II manipulated, in addition to index values, the order in which words were repeated. First grade children were used as Ss.

Significant effects of the index variable were observed when dependent variables sensitive to content (defined as lexical items) were used. When structure-sensitive measures were taken, the index produced no effect. Recall, when repetitions of words were in the same order in both clauses, was significantly better than when repetitions were in different orders. The results were taken as support for a general version of a frame and footnote strategy. Subjects appeared to be operating independently on the structure and content of the sentences when encoding them in short-term memory.

The relation of subject ratings of sentences to short-term recall for the same sentences was the focus of Experiment III. College Ss were asked to rate the sentences from Experiment II on scales of acceptability or grammaticality. A significant effect of the order of repetitions on ratings was observed. Sentences containing repetitions in the same order were rated higher than sentences containing repetitions in different orders. The index effect on ratings was marginally significant, but the effect was not a linear change. There was no difference between grammaticality and acceptability ratings. It was concluded that ratings reflected performance factors as well as underlying competence.

In Experiments IV and V, Ss were tested for immediate recall of compound digit, letter and word strings. The strings varied along the index dimension (number of repeated units) and the order dimension (same or different). First grade Ss were used in Experiment IV, as in Experiments I and II. Subjects' responses were shorter than the originals, never exceeding, on the average, half the length of the stimulus string. In spite of the task difficulty, significant effects of the index and the order variable were observed. The trends were similar to those that were found in Experiment II, except that the absolute number of units in the responses from Experiment II was greater than that found in Experiment IV.

Experiment V used the same materials as Experiment IV, but older Ss were tested so that memory load was less of a problem. The college age Ss showed similar trends to those found for first-graders. There was, though, no effect of the index for digit strings for the older Ss. The college Ss also showed no effect of the index when units were repeated in different orders between the "clauses" of the strings.

The significance of these findings is that they point to a general short-term memory encoding strategy for compound sentences and digits, letter and word strings with compound structures.

GENERAL INTRODUCTION

The effects of repeating single items or units in short-term memory tasks have been extensively investigated for traditional verbal materials. Repetition of individual trigrams increases recall in the Peterson and Peterson task (Peterson & Peterson, 1959; Hellyer, 1962). In paired associates tasks, performance has also been found to be a direct function of repetition (Peterson, Saltzman, Hillner & Land, 1962; Peterson, Wampler, Kirkpatrick & Saltzman, 1963). Waugh (1962, 1963) has found similar effects in free recall of lists of unrelated English words. One feature that has not been investigated in the studies just cited is structure. That is, none of the materials involved organizational factors or syntax. All of the materials, while classified as verbal (e.g., nonsense syllables) were presented singly or as unrelated items in lists. Syntactically organized strings (or sentences) were not used.

Only a few investigators have been concerned with the effects of repeated items constituting a form of structure within a string. Using digit strings, Wickelgren (1965) has found the effects of repetition to be dependent on the manner in which digits are repeated.

An unusual finding, known as the Ranschburg Effect, has been discussed and investigated by Jahnke (1968). The Ranschburg Effect is a reduction in recall for a single repeated item in a string of digits. In explaining his results, Jahnke proposes three separate mechanisms that may contribute to the depressed recall scores. First, Ss may fail to detect the repetition; second, Ss may detect the repetition, but fail to include it in their response and third, Ss may fail to remember which item was repeated and give an incorrect repetition in his response (Jahnke, 1968, p. 24-25).

The three mechanisms bear some resemblance to the framing and footnoting strategies invoked by Miller (1962), Mehler (1963) and others to account for differential recall of sentences involving transformations. The traditional frame and footnote explanation holds that Ss reduce a sentence to a "kernel" plus footnotes about the transformations necessary to reproduce the original sentence. Analogously, Ss could code digit strings into specific string components plus a footnote about repetition. Once the parallel is drawn, it seems possible that the psycholinguistic mechanisms of framing and footnoting could best be explained in a general cognitive psychological framework instead of a specific linguistic theory. That is, the frame and footnote strategy might be a general coding device for any organized string instead of being unique to sentences.

The series of experiments to follow constitutes an attempt to answer two major questions with regard to the issues raised above.

First, what are the specific effects of repeating units in strings which have underlying structures? Second, what is the nature of differences in encoding processes in short-term memory for natural language material compared with non-linguistic material?

Five studies, each asking specific questions related to the two general questions, are presented in the following pages. Experiment I is an extension of earlier work with compound sentences (Kamil, 1969). A new set of materials was employed in this experiment to determine the generality of the earlier results which showed that recall was a function of the number of words in the two clauses of a compound sentence. Experiment II is a study of the effects of manipulating both the number of repeated words and the order of repetition in sentences based on those used in Experiment I. That is, in Experiment I, words are always repeated in the same orders in both clauses, so repeated words are confounded with repetition in the same order. Experiment II uses repetitions of the same words in different orders. The combined manipulations yield evidence about the nature of the encoding processes for sentences in short-term memory. Experiment III is a grammaticality rating study. Because performance differences were found in fully grammatical sentences in Experiments I and II, the relation between Ss' judgments of the sentences and their performance is of interest. The ratings Ss give to fully grammatical sentences show patterns similar to those found in different task situations, like Experiments I and II.

The last two experiments involve strings of digits, letters, and words with units repeated in the same or in different orders. Number of repetitions is also manipulated. Experiment IV was conducted with a population of young children, as were Experiments I and II. Because young Ss found the task too difficult, Experiment V was run with a population of adult speakers. The questions for Experiments IV and V were similar to those for Experiment II, except that non-linguistic materials were used instead of sentences. Both Experiments IV and V were designed to reveal the nature of the differences (if any) in processing sentences and digit, letter, or word strings.

EXPERIMENT I

INTRODUCTION

A study by Menyuk (1963) has demonstrated the feasibility of using short-term memory tasks with young children for investigating linguistic variables. Menyuk's (1963) study indicated that data obtained from the short-term memory task agree with data obtained by other means (e.g., analysis of free speech). Thus, for example, significant correlations were found between the number of children who used each syntactic structure in their grammar and the number who repeated (recalled) each structure.

Kamil (1969) investigated the effects of a syntactic variable for young children in an immediate memory task. For compound sentences with clauses of parallel syntactic structure, an index was defined which reflected the number of words repeated between clauses. Thus, sentences like <u>The fast silver plane landed and a fast dark plane landed</u> were remembered better than sentences like <u>A cute little toy broke and the round blue plate broke</u>. The results of Kamil's study showed recall to be a positive function of the number of repeated words.

Inferences about the nature of the short-term memory mechanisms for sentence analysis can be made on the basis of the results.

Further experimentation, though, is unwarranted if the index phenomenon is tied to a specific syntactic structure. The present experiment is an attempt to determine the generality of the index effect.

METHOD

Materials. A set of 12 compound sentences was constructed. Each sentence was of the form: $\underline{S_1 \text{ and } S_2}$, where S_1 and S_2 both had the underlying structure:

$$S = ART_1 + ADJ_1 + ADJ_2 + NOUN_1 + VERB + PREP + ART_2 + NOUN_2.$$

An index of surface similarity for compound sentences can be defined if the clauses in the sentences are composed of the same form classes:

$$\text{Repetition Index} = 100 \times \frac{\text{Number of identical words in both } S_1 \text{ and } S_2}{\text{Number of words per clause}}$$

This is identical to the index used by Kamil (1969), when syntactic structure of the two clauses is identical.

Four values of the index were used: 13, 37, 63 and 87, corresponding to 1, 3, 5 and 7 of the eight words in S_1 being identical to words in S_2. An example of a sentence with an index of 37 was <u>A warm green bug hopped in the grass and the old green car drove on the grass</u>.

For each of the four index values, three sentences were generated, varying the parts of speech contributing to the index. Thus for one of the '13' sentences, n_1 in S_1 was identical to n_1 in S_2. In another of the '13' sentences, both verbs were the same and in the last, both n_2 in S_1 and n_2 in S_2 were the same. Combinations of all the parts of speech were used to contribute to the higher index values.

Individual lexical items were all high frequency words. They were selected from three sources: Burkingham & Dolch (1936), Rinsland (1945), and Thorndike and Lorge (1944). Criteria for acceptability of words were established for each list to ensure that the particular words chosen would not be foreign to vocabularies of children in the first grade. The criteria varied with the lists. For Buckingham and Dolch, the words had to have appeared in either the Kindergarten Union list or in the Horn list. For Thorndike-Lorge, the frequency of occurrence had to be above 30 per million. From Rinsland's list, words were chosen from the 3000 most frequent words for first-grade children. The full set of sentences is given in Appendix A.

Two randomized orders of the sentences were constructed. In addition to the twelve sentences described above, ten other sentences of different structure, not compound, were interspersed throughout each order. No two sentences of the same index value occurred consecutively. Two practice sentences were used at the beginning of both orders to provide some warm-up.

Procedure. Testing was done individually. Each S was told to listen to the sentence and repeat it after E finished reading it aloud. Data sheets were provided for E with the sentences printed correctly in the order to be used. The E corrected the models on the data sheets to correspond with the sentence as repeated by the child. If a child gave no more than two words in response to a sentence,

testing continued with the next sentence. At the end of the list, _S_ was given the missing sentence again. One additional repetition was provided if _S_ still gave no more than two words in response. Sentences were read with a natural intonation. Each test session lasted about 12 minutes.

Subjects. Ten first grade students from a Madison public school were used. The mean age for all _S_s was 6.4 years. Subjects were assigned to the two orders at random.

RESULTS

A preliminary measure of the difficulty of the memory task, the mean response length in words was calculated for all Ss. A mean of 15.7 words was found when all words in the response were counted whether they were correct or not. In all cases, the index sentences contained 17 words. Thus, responses approximated the stimuli in length.

Two measures were taken on each sentence, total words correct and words correct in sequence. Words were counted as correct for the first measure if they occurred in any order, in either clause. If a word was in the response more times than it was used in the original sentence, only the number occurring in the original was scored as correct. A word was scored as correct in sequence if it occurred in the response in the same relative position it occupied in the original. Additions of words not in the original and deletions were disregarded in applying the sequence criterion. For each S, scores were summed for all three sentences at a given index value.[1]

A subjects x index repeated measures analysis of variance was conducted for each of the dependent variables. The means for total words correct as a function of the index were 32.8, 35.7, 37.9 and 42.9 (out of 51 possible) for the index values of 13, 37, 63 and 87, respectively. The overall index effect was significant ($F(3, 27) =$

24.85, $\underline{p} < .001$).[2] A trend test revealed that only the linear component was significant ($F(1, 27) = 71.02$, $\underline{p} < .001$).

The means for words correct in order were 30.6, 34.3, 36.6, and 42.4 (out of 51 possible) for the four values of the index from lowest to highest, respectively. Again, the index effect was significant ($F(3.27) = 18.78$, $\underline{p} < .005$) corrected for repeated measures. The trend test showed only a significant linear component ($F(1.27) = 54.58$, $\underline{p} < .001$).

It is of some interest to determine whether the two measures, total words correct and total words correct in sequence show the same trends. Since the manipulations in Experiment II involve changing order of words in sentences, the choice of a dependent variable might be a critical factor. A Pearson Product-moment correlation was calculated between total words correct and words correct in sequence for each S. The mean correlation for all ten Ss was r = .96.

DISCUSSION

The results show the index effect for the new set of materials which differed in syntactic structures was substantially the same as in the earlier study. In the earlier work (Kamil, 1969) two possible explanations were advanced for the effects of the index. One possibility was that Ss were using a frame and footnote coding strategy. That is, with many words repeated in the same order, Ss could reduce their memory load by extracting a grammatical frame and remembering lexical footnotes to reconstruct the sentence. As fewer words were repeated between clauses, the framing and footnoting strategy would become more difficult, since more footnotes would be needed for reconstruction.[3]

The second explanation was based on a response bias mechanism. Subjects might remember only one clause. If guesses for the other clauses are based on the words in the remembered clause, as the number of repeated words is increased, Ss get more words correct by "guessing." There is also evidence that Ss are retaining information about the structural relations (order) of the words in the sentences. That is, there are no differences in the conclusions based on the two different measures total words correct and words correct in sequence. If Ss remember words, they remember them in the correct order. This is not surprising, since similar findings have been reported in other situations (e.g., Marks & Miller, 1964).

As discussed above, two explanations are available for the Index effect. The evidence accumulated in this study will not allow a choice between them. However, the generality of the index effect does permit further experimentation. Specifically, a study to distinguish between the frame and footnote and response bias explanations can be conducted.

EXPERIMENT II

INTRODUCTION

The original study using the index variable (Kamil, 1969) and Experiment I, taken together, demonstrate the generality of the repetition effect for compound sentences. Two possible explanations were advanced to account for the original index effect, a frame and footnote strategy and a response bias mechanism. Further experimentation to determine the more reasonable explanation was dependent on the replication of the index effect for the different sentences in Experiment I.

A frame and footnote strategy implies that Ss analyze sentences into two distince components. The frame contains all the repeated items in the two clauses, plus slots for not repeated items. Footnotes are used to add the non-repeated items to reconstruct the sentence. Thus, the analysis of a sentence like The wide smooth road ended near near the river and the wide smooth road ended near the lake might contain the following steps. First, a frame The wide smooth road ended near the _____ is extracted. Second, footnotes in the form of an ordered list of substitutions would be stored. In this case, the list would be comprised of river and lake. Finally, a set of notes like "repeat the frame and add and between the clauses" would also be stored.

It is obvious that as the number of repeated words decreases, the frame and footnote strategy becomes more difficult. When only one word is repeated, for example, the strategy amounts to remembering ordered lists. As more footnotes and longer lists of words are needed to reconstruct the sentence, less memory space is available. Thus, lower index values should predictably show poorer recall.

The response bias mechanism involves a guessing strategy by Ss. If a S does not remember words in the second clause, as he produces his response, he guesses words occurring in the clause he did remember. Again, for high values of the index, high recall scores are a result of this guessing mechanism. As the index decreases, the guessing strategy becomes less effective.

Because the words in the sentences are always repeated in the same order in the two clauses, a choice cannot be made between the two explanations, as the predictions are the same for both. To determine which of the two explanations best fits into a model of a human language processor, sentences with words repeated in different orders (between clauses) are needed. If the order of repetition affects recall, Ss are using a frame and footnote strategy, since guessing of words should be unaffected by the change in order. Frames and footnotes, on the other hand, would be more difficult to generate when the repetitions are in different orders. Similarly, if no difference in recall is apparent, the response-bias explanation is more reasonable. The purpose of the present experiment is to test the two explanations in the context described above.

METHOD

Materials. Three sets of sentences were used in this experiment. An example from each set is given below:

i) The cute sleepy baby played under the table and the cute sleepy cat played under the table.

ii) The sleepy baby played under the cute table and the cute sleepy cat played under the table.

iii) Under the cute table the sleepy baby played and the cute sleepy cat played under the table.

The first set, of the type given in i), is the same set used in Experiment I and will be referred to as the NORMAL set. The second set, of the form given in ii), involves shifting the first adjective in one clause of a normal sentence to modify the second noun in the clause. The second set will be referred to as the ADJECTIVE SHIFT set.

The last set was generated from the adjective shift set, and an example is given in iii), above. For each sentence the prepositional phrase, in the clause with the adjective shift, was shifted to the beginning of the clause. This set will be referred to as the PREPOSITION SHIFT set.

The preposition shift incorporates the adjective shift, so all three sentence sets fall along a dimension of "parallelness," the normal set being parallel and the preposition shift set being most disrupted. This dimension is subsequently referred to as the order dimension. All of the lexical items were retained in generating the three sets. Only the order of the items was changed in the second two sets, so the index is unchanged. That is, index refers to repetition of lexical items; order refers to repetition of grammatical structure.

Three different sets of 12 sentences each were constructed by selecting for each list, at each index value, three sentences, one normal, one adjective shift, and one preposition shift. In a particular list, the three sentences at one index value were composed of different lexical items. Thus, the same lexical items appeared in different orders on different lists. Each list was a randomized order of sentences, with no consecutive instances of the same index value or order (normal, adjective shift or preposition shift). All three sets are included in Appendix B.

Each set was recorded on tape by a male speaker whose dialect is best characterized as Upper Midwest.

Procedure. Ss were tested individually, as in Experiment I, but each S was tested three times, once on each list. Testing sessions lasted about 10 minutes on three consecutive days. Instructions were the same as for Experiment I, except that Ss heard the materials over a tape recorder. The E transcribed the responses

as in Experiment I.

Subjects. Fifteen first grade Ss from a Madison public school serves as Ss. The mean age for all Ss was 6.6 years.

RESULTS

As in Experiment I, a check on task difficulty was made by determining the length of all responses in words, regardless of whether the words were correct. The mean for all sentences was 14.7 words. A total of 17 words was presented in each sentence. Thus, Ss were approximating the length of the stimulus.

Four measures were taken on the response data: total words correct, words correct in sequence, total form classes correct, and form classes correct in sequence. The first two measures involving words were obtained in the same manner as those used in Experiment I. Criteria for form class measures were identical to the word measures except the counts were performed on the grammatical form classes rather than the specific lexical items. It is important to note that the four measures are not independent. For every correct word recalled, a correct form class is recalled. The reverse is not true. Scores were obtained by summing over the three instances of a particular index and order combination. A subjects x index x order repeated measures analysis of variance was conducted for each of the four dependent variables.

Table 1 gives the means and F-ratios for the sources found to produce significant effects in the analysis of total words correct. Subsequent tests by the Newman-Keuls method among the means for the other variable showed that normal sentences were easier to recall than adjective shift sentences or preposition shift sentences and adjective shift sentences were easier than preposition shift sentences ($p < .01$ in all cases).

The means and F-ratios for significant effects in the words correct in sequence analysis are given in Table 2.[4] Subsequent tests among the means for the order variable showed significant differences among all three pairs of values ($p < .01$). Figure 1 shows the mean words in sequence recalled for the normal, adjective shift and preposition shift sentences as a function of the index. Although the linear effects are present for the normal and adjective shift sentences, the trend test for linearity for preposition shift sentences was not significant ($F(1, 42) = 0.07$, $p < .05$).

To determine whether total words correct reveal the same trends for words correct in sequence for the three levels of the order variable, a correlational analysis was conducted. Pearson Product-moment correlations were calculated for each S at each of the three levels for the order variable. In order to examine differences between levels on the order dimension, the correlations were used as dependent variables. A Z-prime transformation was applied to normalize the raw correlations, and a subjects x order analysis of

Table 1

Summary of Variance Estimates, Error Terms, F-Ratios and Means (For Main Effects) for Significant Sources in the Analysis of Variance of Total Words Correct.

Source	df	MS	F	p	Means
Index	3	456.69	31.30	$< .001$	87-39.67 63-36.93 37-33.40 13-32.87
Linear trend	1	1280.64	87.84	$< .001$	
Error	42	14.59			
Order	2	432.67	29.88	$< .001$	normal 38.53 adjective 35.45 preposition 33.18
Error	28	14.48			

Table 2

Summary of Variance Estimates, Error Terms, F-Ratios and Means (For Main Effects) for Significant Sources in the Analysis of Variance of Words Correct in Sequence.

Source	df	MS	F	p	Means
Index	3	371.84	13.36	$< .001$	87-33.29 63-29.60 37-28.11 13-26.58
Linear trend	1	1051.92	37.80	$< .001$	
Error	42	27.83			
Order	2	3938.42	115.78	$< .001$	normal 36.32 adjective 31.38 preposition 20.48
Error	28	34.02			
Index x Order	6	165.86	9.70	$< .01$	
Linear x Normal	1	1582.04	92.52	$< .001$	
Linear x Adjective	1	218.40	12.77	$< .005$	
Error	84	17.10			

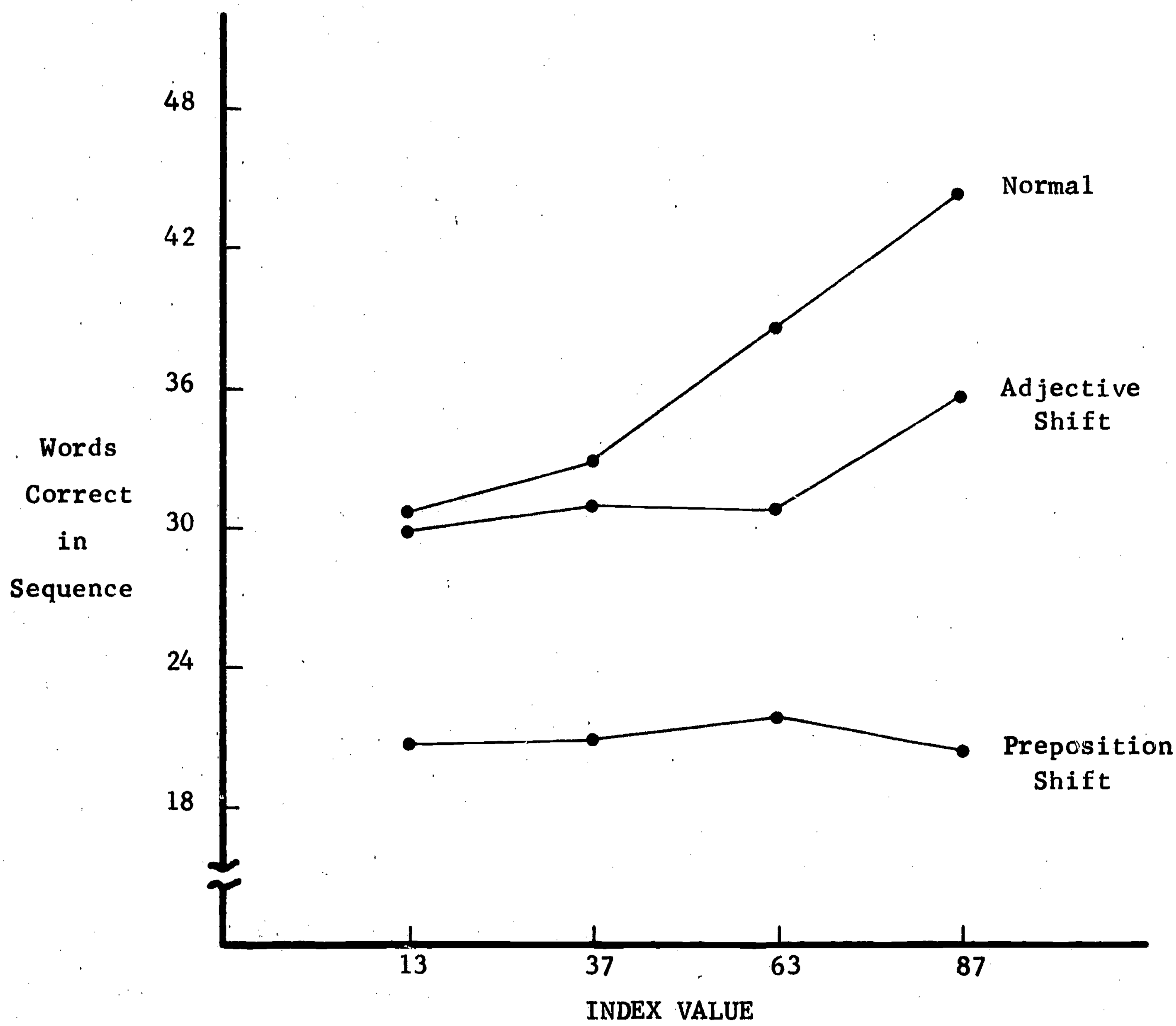

Fig. 1 Mean Words Correct in Sequence as a Function of Index Value and Order of Repeated Words in Experiment II. (Maximum = 51 words)

variance was conducted on the transformed scores. The mean correlations for the three conditions were normal sentences, $r = .891$; adjective shift sentences, $r = .778$; and preposition shift sentences, $r = .495$. The overall effect was significant, $F(2, 28) = 21.40$, $p < .001$. Subsequent tests by the Newman-Keuls method showed that the correlation was significantly greater for normal sentences than for adjective shift sentences ($p < .05$) or preposition shift sentences ($p < .01$) and that adjective shift sentences had a higher correlation than preposition shift sentences ($p < .01$).

The analysis of variance for total form classes correct revealed only a significant effect for the order variable, $F(2, 28) = 17.76$, $p < .001$. The three means for normal, adjective shift and preposition shift sentences were 46.23, 44.4, and 41.55 form classes correct out of 51. Subsequent tests showed significant differences between normal and adjective shift sentences ($p < .05$), between normal and preposition shift and between adjective and preposition shift sentences ($p < .01$). No interactions were significant.

The analysis for form classes correct in sequence again revealed only a significant effect of the order variable, $F(2, 28) = 210.42$, $p < .001$. The mean for normal sentences (46.03) was significantly greater than the mean for the adjective shift sentences (41.78) and the mean for the preposition shift sentences (25.30), $p < .01$ in both cases. The mean for the adjective shift sentences was also greater than that for the preposition shift sentences ($p < .01$). Again, no interactions were significant.

Correlations were calculated between total form classes correct and form classes correct in sequence for each S as a function of the three levels of the order variable. Normal sentences produced a mean correlation of .941, adjective shift sentences showed a mean of .787 and preposition shift sentences showed a mean of .476.

Since many of the correlations for the normal sentences were 1.0, the Z-prime transformation produces values of infinity. Therefore, non-parametric tests (Mann-Whitney) were applied to all three pair-wise comparisons. Significant differences resulted in all cases, normal greater than adjective or preposition shift sentences and adjective shift greater than preposition shift ($p < .001$).

One final analysis of the response data was performed. The number of responses which contained parallel form class structures in S_1 and S_2 were tabulated for each level of index and order. A response was considered parallel if, for every form class in S_1, there was an identical form class in the same serial position in S_2. An analysis of variance was conducted, showing the overall index effect to be significant, $F(3, 6) = 11.51$, $p < .01$. The mean number of parallel structures per list for the index variable from 13 to 87 were 15.3, 15.0, 18.7 and 28.7, respectively (maximum possible = 45). Trend analysis revealed a significant linear component, $F(1, 6) = 26.86$, $p < .005$. The order variable also had a significant effect $F(2, 4) = 10.81$, $p < .025$. The mean numbers of parallel responses for normal, adjective shift and preposition shift sentences were 26.5, 18.0, and 13.8, respectively. Subsequent tests revealed

significantly more parallel structures in normal sentences than in adjective or preposition shift sentences ($p < .05$). There was no difference in means for adjective shift and preposition shift sentences ($p > .05$).

DISCUSSION

In all the analyses reported here, there is a striking effect of order. Normal sentences are always recalled better than either adjective or preposition shift sentences, and adjective shift sentences are recalled better than preposition shift sentences. The major implication is that the response bias explanation suggested in earlier experimentation is inadequate. Subjects do not seem to respond on the basis of words they know to be correct in one of the clauses. If Ss were responding with a response bias mechanism, the order variable should have no effect on total words correct. The words in each clause, for all sentences of a particular index value, are the same. As order is manipulated, a response bias mechanism should be unaffected, since the guessing technique, for total words recalled, would produce the same result for all order values.

For the total words correct measure, the index effect was replicated. Recall varied as a function of the number of repeated words. Three other measures were used to assess recall: total words correct in sequence, total form classes correct, and total form classes correct in sequence. Total words correct in sequence does show both an index and an order effect. However, the presence of the index x order interaction indicates the effects are not the same

as for total words. Analyses showed that preposition shift sentences were not affected by the index variable. The index variable showed no effect when the form class measures were analyzed. Since all four measures detect different manipulations, it is important to clarify what is being measured in each case.

The four measures may be thought of as filling the cells of a 2 x 2 matrix. One dimension, words versus form classes, represents measures of content plus structure (specific lexical items and form classes) versus measures of structure (specific sentential components or form classes). The other dimension, total correct versus correct in sequence contrasts two levels of structure, specific components and overall organization. The two word measures thus contrast structure and structure plus content, while the form class measures are insensitive to content.

Since form classes are insensitive to content, it is reasonable that the index effect does not show up in the form class analyses. The interaction in the words correct in sequence analysis is also predictable, since both structure and content are being measured.

Because there are differences in structure and content measures, it seems appropriate to question the generality of the frame and footnote explanation. As it has been used in this paper, a frame consists of a series of repeated lexical items. Footnotes are directions for recreating the structure. It is possible to describe the strategy from a different point of view.

In analyzing a sentence for storage in short-term memory, Ss seem to operate on the content of a sentence differently from the way in which they process the structure. The frame and footnote strategy can be viewed as one specific instance of structure and content coding.

Other research has shown evidence for different processes in memory for structure and content (Sachs, 1967). Sachs found that syntactic forms of sentences were stored only for the time before comprehension occurred. The present findings reinforce the notion that Ss do process structure and content in different ways. Because the present task is an immediate recall task, it can be hypothesized that comprehension is not complete before Ss are to respond. Such a conjecture would account for the fact that more correct form classes than correct words are reported. Subjects would remember the structural components (form classes) while losing the specific lexical items (words). In reproducing the sentences, Ss then substitute items from the same form class. As the number of repeated words increases, though, less comprehension has to occur for the whole sentence, since some of the meaning from one clause is also applicable to the other clause. The index effect can then be seen as reflecting the increasing difficulty of extracting meaning as fewer words are repeated.

The materials used in this experiment, because of the design, have complete form class repetition between clauses. That is, every form class in S_1 is also used in S_2. It may be that the increased recall of form classes is simply a function of the closed set of form classes used in all of the sentences. The order variable effectively,

however, differentiates recall when number of form classes are measured. Thus, Ss do not seem to be relying solely on the set of form classes in one clause to give them the form classes in the other. A response bias interpretation is not applicable even on a structural level.

One important factor that may account for the order effect is parallel structure. Parallel structures seem to make the normal set of sentences psychologically easier to process. Some device, a surface-structural analyzer, for example, to signal parallel structures in incoming sentences is important for a model of the encoding process for short-term memory.

There are also implications for a performance theory of compound sentences in the present results. Chomsky (1957, p. 36) stated that

> If S_1 and S_2 are grammatical sentences, and S_1 differs from S_2 only in that X appears in S_1 and Y appears in S_2 (i.e., S_1 = . .X. . and S_2 = . .Y. .), and X and Y are constituents of the same type in S_1 and S_2, respectively, then S_3 is a sentence, where S_3 is the result of replacing X by X + and + Y in S_1 (i.e., S_3 = . .X + and + Y. .).

Compound sentences can be produced by these rules if x and y are grammatical sentences and the environment is null. Any two grammatical sentences can then be conjoined to form a third.

Clearly, performance in the present experiment is dependent on more than analyzing the compound sentence into two clauses, each of which is also a sentence. For psycholinguists, the importance of the poorer performance on adjective and preposition shift sentences is that Ss use surface structural information as an initial step in analysis of sentences. If Ss were immediately analyzing deep structures, no difference would be predicted between the adjective and preposition shift sentences, since they have similar deep structures. The normal sentences have essentially different deep structures from the adjective and preposition shift sentences, so those performance differences are predictable. However, the existing performance discrepancies between adjective and preposition shift sentences are sufficient to warrant emphasis on surface structural analysis. Sach's (1967) study also points out the necessity for immediate structural analysis.

In dealing with compound sentences, Ss seem to be initially more sensitive to the surface structural relations between S_1 and S_2 than to the deep structural characteristics. A performance model should provide some means of comparing the structure of S_1 with the structure of S_2 at some time in the analytic process. As a result of the comparison, different processing strategies appear to be adopted. The differences may involve the amount of structural information that has to be stored in order to reproduce the original sentence.

The other important finding of this experiment is methodological in nature. It was reported earlier that Marks and Miller (1964) found no difference in the use of words correct or words in order as dependent variables. The two correlational analyses show the limitations of the Marks and Miller conclusion. There were significant differences in the correlations between total words and words correct in sequence for all pairs of values on the order variable. The same was true for the two form class measures. It is not appropriate, therefore, to use only total words correct as a measure of performance without being aware that manipulations in stimulus materials may reduce the correlation between total words correct and other measures.

EXPERIMENT III

INTRODUCTION

Interest in the ability of Ss to distinguish levels of grammaticality or acceptability is a result of the theory of transformational grammar (e.g., Chomsky, 1957). Chomsky has argued that the adequacy of a grammar may be tested by having native speakers judge whether the sentences generated are grammatical (1957, p. 13). The procedure recommended by Chomsky was to ask speakers whether specific sentences were acceptable. A revised position has been set forth (Chomsky, 1965) in which it is noted that performance measures may not adequately reflect linguistic competence.

Maclay and Sleator (1960) attempted to use Chomsky's original formulation in eliciting judgments of grammaticality from Ss. Their procedure involved eliciting a yes-no response to sentences varying in grammaticalness and meaningfulness. It was found that Ss did judge sentences along a grammaticality dimension in a manner that corresponded to a linguistic ordering of those sentences.

Subsequent uses of similar techniques by Hill (1961) produced results that were less encouraging than those of Maclay and Sleator. Hill's results indicated that reasons for judgments were largely idiosyncratic. Gleitman (1965) asked for judgments of acceptability

but reported no data on the basis for judgments. Since the judgment task may be a performance task, it is important to consider the relation of the judgment data to other performance data.

Coleman (1965) constructed a scale of grammaticality and had Ss rate the word sets. He found that Ss did, in fact, rate the materials in the same order predicted *a priori*. A memorization task showed that ease of memorization varied as a direct function of grammaticality. Coleman concludes that with appropriate instructions, the rating technique is a valid instrument for psycholinguistic research.

The experiments involving rating studies show that Ss do distinguish between grammatical sentences and non-grammatical word strings when rating grammaticality. Coleman's experiment indicates that rating data can predict performance in other tasks. Thus, the use of ratings may provide a convenient check on performance data obtained by other means.

The data from Experiment II have shown that significant performance differences exist among the three sets of sentences used (normal, adjective shift and preposition shift). There were also performance differences as a function of the index values. The experimental question posed in this experiment is how do Ss judge (rate) those same sentences?

A significant departure from the methodology used in earlier rating studies is involved in the proposed question. All of the sentences from Experiment II to be rated are grammatical. If rating tasks reflect competence, no difference would be expected. Coleman's results indicate that performance is involved, so it can be expected that differences in ratings should occur, reflecting performance differences found in Experiments I and II.

METHOD

Materials. The sentence lists for this experiment were those constructed for use in Experiment II. Booklets were prepared with sentences typed across the page. Directly beneath each sentence was a seven-point rating scale labeled with the words ungrammatical or unacceptable to the left and grammatical or acceptable to the right. Filler sentences were interspersed in the booklets to prevent sentences of similar index and order values from occurring consecutively. The filler sentences were constructed as deviant sentences of the form "There is a new teacher which is pretty and smart." This provided sentences that were ungrammatical so that Ss would not artificially attempt to spread the grammatical sentences over the entire rating scale. Each booklet contained the sentences from one of the three lists. In all, there were six different booklets, three utilizing grammaticality scales and three utilizing acceptability scales. Each booklet was four pages long and contained 20 sentences. A cover sheet with printed instructions was the first page of the booklet. An example is given in Appendix C.

Procedure. Subjects were tested in one group session of about 15 minutes. Subjects were instructed to read the first page and to indicate any questions by raising a hand. Since the instructions to half the Ss involved "grammaticality" and those to the others

involved "acceptability," questions were handled individually.

The instructions were for Ss to circle the number on the scale which best represented their "linguistic judgment" of each sentence. A sentence was to be acceptable "if a speaker of English would use it in normal speaking or writing." The criterion for grammaticality was to be that it obeyed "the grammatical rules of English as you have learned them." No time limit was set, but Ss were instructed to work quickly.

Subjects. Forty-eight students enrolled in an experimental psychology course at UW served as Ss. All Ss were native speakers of English.

RESULTS

A repeated measures analysis of variance, subjects nested with rating scales (acceptability or grammaticality) and lists and crossed with index and order, was conducted on the rating data. The effect of the order variable was significant, $F(2, 84) = 28.39$, $p < .001$. Mean ratings for the three order values were: normal, 4.3; adjective shift, 4.2; and preposition shift, 3.4. Subsequent tests by the Newman-Keuls method showed significant differences between normal and preposition shift sentences and between adjective and preposition shift sentences ($p < .01$ in both cases). No difference was found between normal and adjective shift sentences ($p > .05$).

The index effect was marginally significant, $F(3, 126) = 4.24$, $p < .05$, corrected for repeated measures. (The critical $F(1, 42)$, $p = .05$, is 4.08.) The mean ratings given to the four index values, from 87 to 13, respectively, were 3.7, 4.0, 4.3, and 3.9. A trend analysis showed that the linear component was not significant, $F(1, 126) = 1.71$, $p > .05$. The non-linear component was significant, however, $F(2, 126) = 11.00$, $p < .001$.

The effect of rating scales was not significant, $F(1, 42) = 3.52$, $p > .05$. None of the interactions were significant.

DISCUSSION

There are three major findings. First, the order variable produced an effect on ratings. Second, there is some effect of the index on ratings. Third, the type of scale (acceptability or grammaticality) has no effect on ratings.

Because the order variable does not affect grammaticality, in a linguistic sense, it might be predicted that ratings should not be affected. However, Hill's (1961) and Coleman's (1965) experiments indicate both that there is a highly idiosyncratic aspect in linguistic judgments and that performance is measured, in part, by rating tasks. Ratings do decrease as the amount of parallel structure decreases. Initial analysis of a sentence might have an important effect in determining the rating given the sentence. Thus, for whatever reason non-parallel sentences are psychologically more difficult to process, ratings may be given on the same basis. Another possibility is that the non-parallel structures are rated as less grammatical or acceptable because of prior education. High school English teachers are notorious for stressing the need to make parallel

structures. Either possibility of interference with linguistic judgments must enter into the consideration of the application of rating tasks in linguistic work.

The effect of the index on ratings may be predicted from the findings of Experiment II. When form class measures were analyzed in Experiment II, there was no effect of the index. It may be that Ss, when rating sentences, disregarded specific content and focused on the syntactic structures. An important point here is that ratings of grammaticality should be independent of content, when content is defined in terms of specific lexical items. The absence of linear change in ratings as a function of the index can be taken as support for the validity of using ratings in determining grammaticality apart from lexicality.

The third finding, that ratings were not significantly different for acceptability or grammaticality scales, is also relevant to the validity of the rating task. Subjects may approach both kinds of scales in the same way and apply the same kinds of criteria in both cases. On the other hand, rating scales may not be as sensitive to instructional variables as Hill (1961) and Coleman (1965) suggested. That is, even if Ss can differentiate between acceptability and grammaticality, they seem to overlook or disregard the distinction when given instructions as in this experiment.

Rating tasks reflect performance differences only along certain dimensions, so caution is a necessity in using ratings in psycholinguistic research. The present results suggest that purely syntactic variables can be assessed from rating data. However, data obtained from such scales is best used in conjunction with other performance data.

EXPERIMENT IV

INTRODUCTION

Experiments I and II have shown that repeating lexical items in compound sentences produces better recall. The literature on repetition, cited in the General Introduction, suggests the results of Experiments I and II may not be the result of a uniquely linguistic process. Both Wickelgren's (1965) and Jahnke's (1968) work suggest that the way in which digits are repeated in a string determines recall.

If the Ranschburg Effect, discussed by Jahnke (1968), is a general memory phenomenon for repeated units in strings, then the index effect should not occur. A repeated digit, in the Ranschburg Effect, is recalled more poorly than non-repeated digits. If the effect *is* general, adding more repeated digits should depress recall even more. Reasoning from Wickelgren's (1965) work, it can be predicted that the order effect might occur in sentences. That is, repetitions in the same order would be predictably easier, similarly to some of the repetition orders in digit strings However, to apply conclusions based on work with digit strings to sentences may be inappropriate.

Digit strings have no underlying structure (syntax). Sentences always have such a structure, by definition. Thus, while the effects obtained in Experiments I and II might be predicted on the basis of other short-term memory work, the evidence for those predictions is certainly not conclusive.

The present experiment is proposed as a means of gathering information on the processing of structured strings of non-linguistic material. As an attempt to make the data comparable from Experiments I and II to the present experiment, a "syntactic" organization, similar to that used in the experiments above, can be given to digit, letter, and randomized word strings. That is, strings can be presented to Ss which are comprised of two "clauses." Repeated units can then be varied analogously as in Experiments I and II.

Two specific questions are to be asked concerning the effects of repeated digits, letters, and words in compound strings (e.g., 12345 and 12346) on recall. The first question is whether the number of repeated units is directly related to recall as with the index effect for sentences. The second question is whether varying the serial position of the repeated items between clauses affects recall as it does in sentences.

If strings of non-linguistic material are processed in the same way that sentences are, the effects observed in Experiments I and II should be observed in this experiment.

METHOD

Materials. Using the repetition index described in Experiment I, sets of strings were constructed from digits, letters and words (in non-sentential orders). For all strings the form was S_1 and S_2, where S_1 and S_2 were "clauses" composed of five digits, letters or words. Four values of the index, 20, 40, 60, and 80, were used. At each index value, six strings were constructed, with repeated items in the same serial positions in both clauses. This is the set "ordered" of strings. Particular positions chosen for repetitions in a clause were varied in the six instances, e.g., HLBAM and HLBAJ compared with OVNFD and CVNFD.

A set of "unordered" strings was generated from the ordered strings by randomizing the items in one clause of each string. Thus, OVNFD and CVNFD became OVNFD and DCFNV. The full set of strings is given in Appendix D.

Six lists were constructed, each containing 12 ordered and 12 unordered strings of digits, letters, or words. The type of material was not mixed within a list. The strings were randomized and recorded on tape. The speaker was the same person who had recorded the materials for Experiment II.

Procedure. Testing was as described in Experiment II. However, Ss were tested only once for about 10 minutes on a single list.

Responses were transcribed as in Experiments I and II.

Subjects. Subjects were 18 first grade students from a Madison public school. The mean age of all Ss was 6.7 years.

RESULTS

The number of units in each response was counted, regardless of whether the units were correct. A mean response length of 3.6 units was found for digit strings, 5.3 for letter strings, and 4.2 for word strings. The length of the original string in each case was 10 units. Thus, Ss found the task difficult, responding with only half as many units as the stimulus contained.

For each S, the total correct units for all three instances of a particular index-order-string-type combination was tabulated. A repeated measures analysis of variance, subjects nested within string type and crossed with order and index was conducted. The main effects of index ($F(3, 45) = 9.49$, $p < .01$) and order ($F(1, 15) = 18.66$, $p < .001$) were significant. String-type did not show a significant effect, $F(2, 15) = 0.479$, $p > .05$).

The means for the index values of 20, 40, 60 and 80 were 3.39, 3.31, 4.01, and 4.50 units recalled, respectively. Trend analysis showed a significant linear component, $F(1, 45) = 24.38$, $p < .001$.

DISCUSSION

There are two main points to be made with respect to the results reported above. First, Ss responded, in the best conditions, with an average of only slightly more than 5 units, about half of the originals. Young children found great difficulty in recalling the strings as they were presented. It seems that the strings far exceeded their memory span, and that the response represented only that portion that could be retained.

In view of the short length of the responses, the second point is particularly surprising. The Ss did show effects of number of repetitions and order of repetition. In fact, the effects are analogous to the effects demonstrated in Experiments I and II for total words recalled. It would seem that whatever the processing that occurred in storing the strings, some notice of repetition and order was made. Loss of units in memory must have come subsequent to the initial processing.

Just as surprising is the fact that Ss in Experiment II showed a mean of about 15 words in their responses to 17-word sentences. Even though the sentences are longer, Ss seem to be able to recall them more easily. Although the absolute levels of recall for sentences and strings differ, the coding strategies, as revealed by the significant order and index effects, seem to be similar.

A more complete analysis of units recalled in order was not attempted since Ss' responses were not sufficiently long to look at words in correct serial position. It might be conjectured that a structure and content coding was being used and that the losses occurred for both the overall string structure and some specific content. The implications of these results cannot be drawn further since it is not clear that Ss were responding on the basis of the entire string organization. Either of two possible courses were considered as continuations of experimentation on this problem. First, an older population of Ss could be used. With increased memory span, responses should match the originals more closely. The second, and less desirable, course would involve decreasing the length of strings for the same population used in this study. Young Ss would not be taxed with regard to their memory spans, but the order variable might be severely affected since repeated items would occur closer together in the string.

In summary, the present results suggest that for young children, the same or similar coding mechanisms or strategies are involved in short-term memory for compound sentences and strings. However, the conclusion must be tempered with the fact that Ss did not respond with strings matching the originals. Experiment V is an attempt to clarify the results, using older Ss.

EXPERIMENT V

INTRODUCTION

The results of Experiment IV show that there are index and order effects in the recall of letter, digit, and word strings for 6-7 year old Ss. Responses of those Ss never averaged more than about 5 units in length, so order effects cannot be evaluated in the same way as for the sentences in Experiment II. That is, number of units in sequence is not appropriate to measure differential effects of order, since the response units do not contain enough serial positions for meaningful conclusions to be drawn. To obtain the information necessary to determine the effects found in Experiment II, an older group of Ss was tested on the materials described in Experiment IV.

METHOD

Experiment V incorporates almost all of the methodology of Experiment IV. Two changes were made. First, Ss were 12 students in an introductory psychology course at the University of Wisconsin. Second, each S was tested on three lists, one of each type of material, in a single session lasting about 25 minutes. The orders of presentation were balanced across all Ss.

RESULTS

The mean response length for all Ss and strings was 9.2 items. Each string was 10 items long. Thus, Ss' responses approximated the length of the stimulus strings.

For each S, two measures were taken. First, total units correct were summed across the three strings for each index-order-material type combination. The second measure was units correct in the correct serial position. The difference between this measure and the words in sequence measure is that additions and deletions were taken into account for the serial position measure but not for the sequence measure. A subjects nested within blocks and crossed with index, order and string-type was conducted for both measures.

Table 3 gives the summary of means and F-ratios for significant effects in the total units correct analysis.[5] Subsequent tests showed significant differences between digit and letter strings and between word and letter strings ($p < .01$), but not between digit and word strings. The means for each string-type as a function of the index are plotted in Figure 2.

Table 3

Summary of Variance Estimates, Error Terms, F-Ratios and Means (For Main Effects)
for Significant Sources in the Analysis of Variance of Total Units Correct in Experiment V.

Source	df	MS	F	p	Means
Index	3	221.62	40.24	$< .001$	80-26.46 60-24.44 40-23.51 20-22.42
Linear trend	1	661.42	120.04	$< .001$	
Error	30	5.51			
Order	1	840.50	73.24	$< .001$	ordered 26.04 unordered 22.63
Error	10	11.47			
String-type	2	272.39	13.20	$< .01$	digits 25.72 letters 22.46 words 24.82
Error	20	20.64			

Table 3, cont.

Source	df	MS	F	p	Means
Index x Order	3	80.58	11.45	$< .01$	
Linear x Ordered	1	809.74	115.02	$< .001$	
Linear x Unordered	1	61.81	8.78	$< .05$	
Error	30	7.04			
Index x String-type	6	28.81	5.84	$< .05$	
Linear x Letters	1	371.43	75.34	$< .001$	
Linear x Words	1	345.25	70.03	$< .001$	
Error	60	4.93			

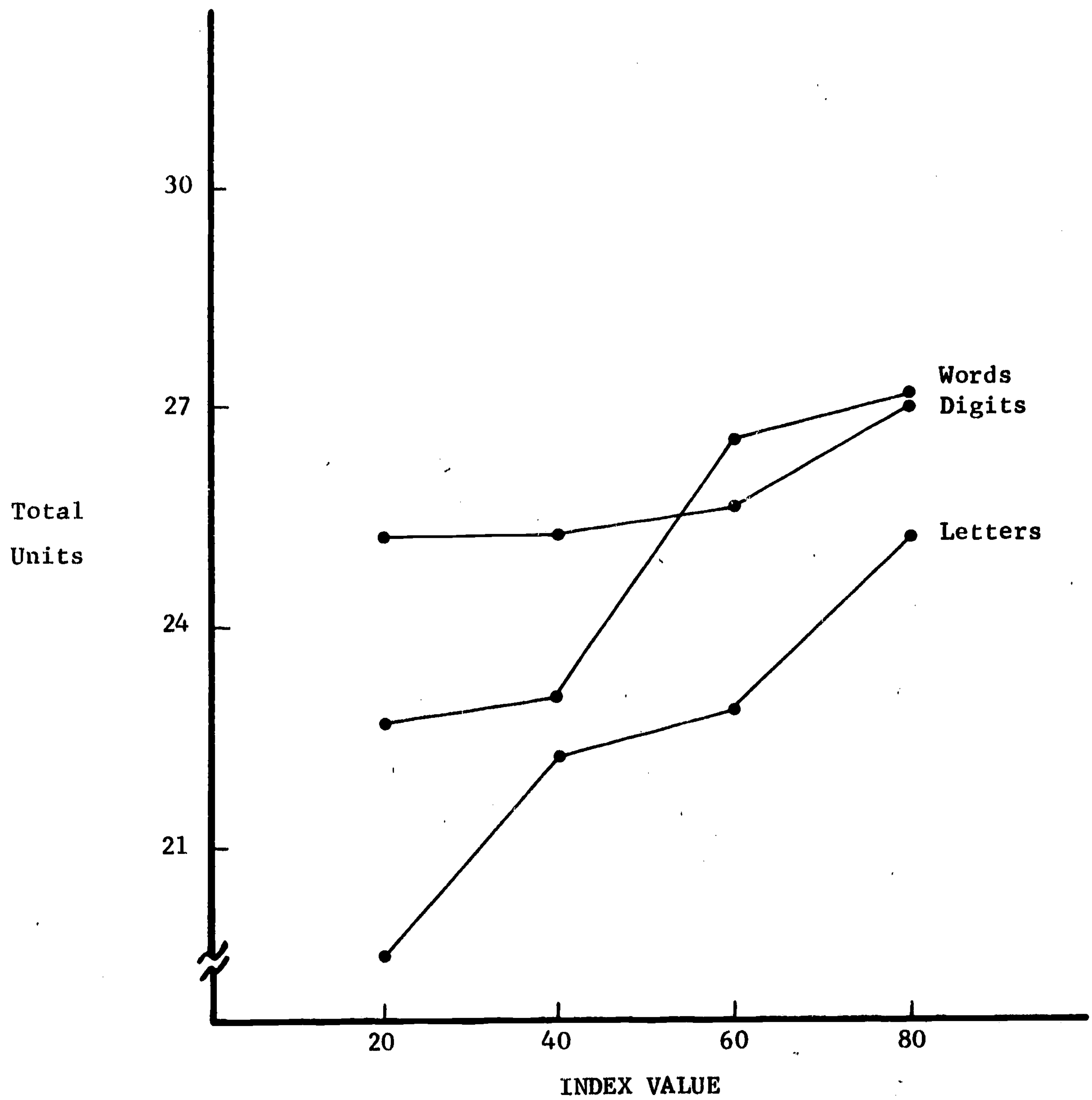

Fig. 2 Mean Total Units Correct as a Function of Index Value and String-Type in Experiment V. (Maximum = 30)

Table 4 summarizes the significant effects for the analysis of units correct in sequence. Subsequent tests showed significant differences between digit and letter strings and between digit and word strings ($\underline{p} < .01$, both cases) but not between word and letter strings. The means for the index as a function of string type are plotted in Figure 3.

Table 4

Summary of Variance Estimates, Error Terms, F-Ratios and Means (For Main Effects) for Significant Sources in the Analysis of Variance of Units Correct in Sequence in Experiment V.

Source	df	MS	F	p	Means
Index	3	245.67	29.94	< .001	80-22.12 60-20.43 40-18.25 20-18.37
Linear trend	1	648.92	77.16	< .001	
Error	30	8.41			
Order	1	324.84	278.03	< .001	ordered 23.15 unordered 16.44
Error	10	11.68			
String-type	2	331.17	24.66	< .001	digits 21.88 letters 18.30 words 19.21
Error	20	13.43			

Table 4, cont.

Source	df	MS	F	p	Means
Index x Order	3	366.31	22.71	< .001	
Linear x Ordered	1	1705.38	129.00	< .001	
Error	30	13.22			
Index x String-type	6	62.02	5.14	< .05	
Linear x Letters	1	539.77	44.72	< .001	
Linear x Words	1	232.95	19.30	< .001	
Error	60	12.07			

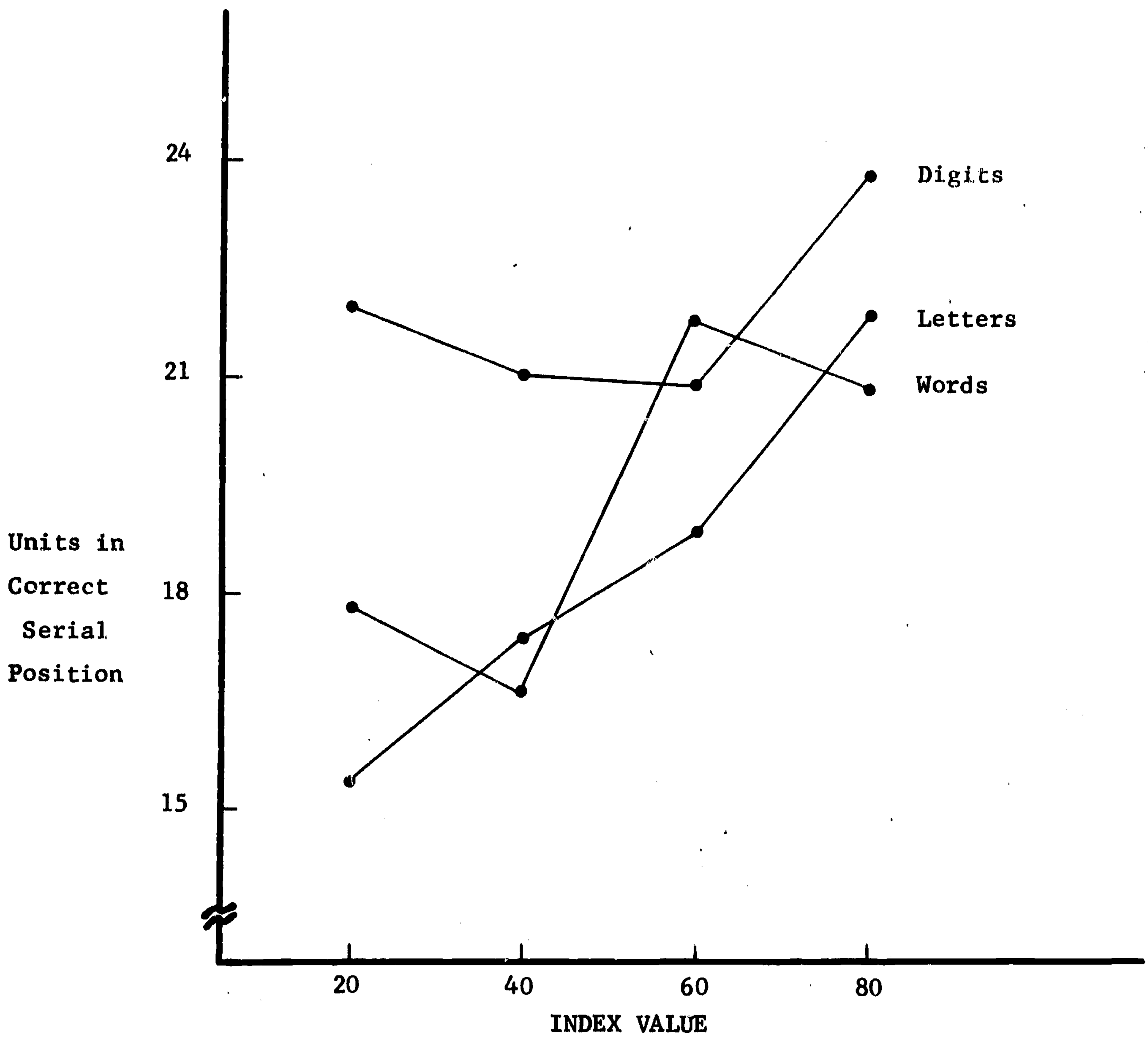

Fig. 3 Mean Units Correct in Sequence as a Function of Index Value and String-Type in Experiment V. (Maximum = 30)

DISCUSSION

In two major respects, the results of Experiment V are similar to the results of Experiment IV. The effects of order and index for total units recalled are the same in Experiment V as in Experiment IV. Important differences appear in the results of the two experiments. College Ss responded with approximately the same number of units as were presented in the original strings. Differences among string-types were found for college Ss but not for the first-grade children. Additional differences were the presence of interactions between index and order and between index and string-type in the college data.

The length of responses by college Ss afforded an opportunity to measure units recalled in correct serial position. The effects for order and index for units in correct serial position were the same as for total units correct. Only a difference in the interaction of index and order was revealed.

It would seem that college students process strings of the type used in this experiment similarly to the ways in which first graders process sentences. That is, college Ss seem to process the structure of the strings--the length and number of units per clause--differently from the way in which they process the "content" (specific units).

Even though some of the items from the original string are forgotten, college Ss retain enough structural information to respond with enough units to match the length of the original. The results of Experiment II showed the same trends for sentence strings with young children as Ss.

For the total units correct analysis, the linear trend along the index is significant for both ordered and unordered strings. Only the ordered strings showed the effect in the units in correct serial position analysis. This result can be taken as evidence that college Ss are using the repeated digits, but not reporting them in the proper order. A similar interaction appears for young Ss in the sentence data when words correct in order are measured.

In both of the analyses conducted in this experiment, total units correct and units in correct serial position, digit strings failed to show the index effect. Digit strings, when compared to word or letter strings, may be viewed as subject to slightly different processing for short-term memory storage and retrieval. There are problems of interpretation. Digit strings could have been composed of more familiar items than either word or letter strings. It is also possible that the "guessing" rate could have been higher for digits than for either of the other types of strings, since the pool from which digits are drawn is smaller than that for letters or words. In either case, it might be possible that the effects of the index variable were obscured by inflated recall measures.

An index by order interaction also appeared in the words correct in sequence analysis of Experiment II. Taken with the similar interaction in this experiment, it suggests that there are rather sharp boundary conditions on the index effect. That is, Ss do not seem to take notice of repeated items when they are not in the same or similar orders in both clauses. This is similar to Wickelgren's (1965) finding that Ss recall of digit strings could be manipulated by making repetitions easier or more difficult to "notice."

In summary, Experiment V demonstrates that the effects observed in Experiments I, II and IV are not specific to the types of materials employed or the age of Ss used. College students showed trends similar to first grade Ss in the recall of digit, letter and word strings. The order effect appeared in all analyses in all experiments, and the index effect was observed in all but two types of strings (in the college Ss' data). The implications of these findings for a short-term memory processor will be discussed in the next section.

SUMMARY AND IMPLICATIONS

Two questions were posed in the general introduction to this paper. First, what are the effects of repeating units in strings which have underlying structures? Second, what are the differences in encoding processes in short-term memory for natural language materials compared with non-linguistic materials? The experiments reported here have not yielded absolute answers, but important evidence pointing toward the final answers has been obtained.

Experiment I demonstrated the generality of an earlier finding that immediate recall for compound sentences is a direct function of the number of words repeated across the two clauses. Experiment II showed that the index value was not the sole determinant of recall. Repetition of words in the same orders in both clauses facilitated recall while repetition in different orders depressed recall. The results were interpreted as supporting a coding strategy which operates independently on structure and content in sentences.

Rating data gathered from college Ss in Experiment III showed effects similar to those for first grade Ss in Experiment II. That is, when the order of repeated words in compound sentences is not the same, lower ratings result. The index variable affected ratings, but the effect was not linear as in Experiment II. It was concluded

that grammaticality rating tasks reflect syntactic manipulations but not content manipulations, when content is defined in terms of lexical items.

Experiment IV attempted to compare non-sentence strings with sentences which varied along the dimensions of index and order. Young children were unable to recall more than 50% of the non-sentence strings. The index effect and the order effect were present in spite of the abbreviated responses.

An older population of Ss was used in Experiment V to assess the effects in non-sentence strings when Ss were not under extreme memory loads. For the most part, college Ss showed the same trends that the first grade Ss did. Apart from the greater absolute level of recall, the major differences were that the older Ss did not show the index effect in some conditions. Specifically, the index effect was not observed when digit strings were presented or when strings with unordered repetitions were used.

An overall view of the results reveals a striking similarity between the results for sentences and for non-sentence strings. That is, the effects of index and of order are present for both types of materials, with the exceptions noted above. The similarity suggests that there may be a general mechanism for processing compound strings for short-term memory.

A strategy for encoding sentences for storage in short-term memory was discussed in Experiment II. It was maintained that Ss analyze structure independently of content. Each is coded and

processed separately. The work by Sachs (1967) was cited as an example of other evidence for the structure-content distinction in memory. The similarity of the trends for digit, letter, and word strings suggests that the structure and content processing mechanism has more generality than indicated in the discussion of Experiment II.

There were differences in the trends for the digit strings in Experiment V. College Ss did not show the index effect for digit strings or for unordered repetitions. The differences might be indicative of some changes with age in the processing of strings. At least two problems of interpretation prevent making the statement as a fact. First, young Ss' responses were not long enough to analyze in the same way that the responses in Experiment V were analyzed. Differences in processing may have been obscured. The second problem is that there may have been differences in the size of the pools from which the elements of the strings are drawn or differences in familiarity with the units themselves. The effects of either factor on the college Ss may have obscured processing differences along the order and index dimensions for digit strings.

In light of these problems in interpreting the differences in performance for college Ss, it is best to emphasize the similarities. Based on the similar trends, a plausible explanation of the results seem to be that Ss try to handle non-sentential strings in the same way they handle sentences. Structure and content coding seems essential for sentences, and it may be a good approximation for non-sentence strings.

FOOTNOTES

[1] Each of the sentences at a particular index value had different repeated parts of speech contributing to the index. There is no way to analyze for the effects of the different parts of speech across the index, since for the highest value all but one word is repeated while for the lowest value, only one word is repeated. Therefore, the scores for all three sentences were summed to balance any possible effects of repeating different parts of speech. This procedure was also followed for the sentences and strings in Experiments II, IV, and V.

[2] In this and all subsequent analyses of variance, the Geisser and Greenhouse (1958) correction for repeated measures was applied where appropriate.

[3] The manner in which framing and footnoting has been used in this paper is not in complete agreement with the way the terms have been used by others (e.g., Miller, 1962). Conventionally, a frame has been used to refer to a "kernel" and footnotes have referred to transformations necessary to reconstruct the original sentences. As used in this paper, the frame is derived from content while footnotes are structural. The present usage is thus more general than the conventional usage, but is not, basically, a different conceptualization.

There is no emphasis, however, in the present usage on transformations as footnotes.

[4]The multiple trend tests for linearity conducted on the interaction effects are not orthogonal. Consequently, the sums of squares are not independent. In spite of the problem of independence, the procedure was adopted as a consistent means for assessing the index effect in interactions.

[5]The method of analysis for interaction effects mentioned in the previous footnote was also used for the analyses in this experiment.

APPENDICES

APPENDIX A

Sentence Set Used in Experiment I

(These are the sentences in the normal set for Experiment II.)

INDEX = 87

A wide smooth road ended near the gate and a wide smooth road ended near the river.

The cute sleepy baby played under the table and the cute sleepy cat played under the table.

The tiny spotted puppy slept at the lake and the tiny spotted puppy drank at the lake.

INDEX = 63

A strange thin man stood on a chair and a strange thin man stood in the room.

The tall happy soldier waited near the building and the tall happy girl waited at a building.

A short thick candle burned under a lamp and a short thick candle melted by the lamp.

INDEX = 37

The funny young artist painted in the field and a pretty young woman painted by the fence.

The long yellow truck arrived at the garage and a new yellow truck parked on the street.

A warm green bug hopped in the grass and the old green car drove on the grass.

INDEX = 13

The small sad boy rested under the tree and a big brown horse rested in a yard.

A bright red ball bounced on the lawn and the little pink ball stopped by a stick.

The empty round bottle fell near the chair and a long straight arrow broke by a chair.

APPENDIX B

Sentence Sets Used in Experiment II

NORMAL

INDEX = 87

A wide smooth road ended near the gate and a wide smooth road ended near the river.

The cute sleepy baby played under the table and the cute sleepy cat played under the table.

The tiny spotted puppy slept at the lake and the tiny spotted puppy drank at the lake.

INDEX = 63

A strange thin man stood on a chair and a strange thin man stood in the room.

The tall happy soldier waited near the building and the tall happy girl waited at a building.

A short thick candle burned under a lamp and a short thick candle melted by the lamp.

INDEX = 37

The funny young artist painted in the field and a pretty young woman painted by the fence.

The long yellow truck arrived at the garage and a new yellow truck parked on the street.

A warm green bug hopped in the grass and the old green car drove on the grass.

INDEX = 13

The small sad boy rested under the tree and a big brown horse rested in a yard.

A bright red ball bounced on the lawn and the little pink ball stopped by a stick.

The empty round bottle fell near the chair and a long straight arrow broke by a chair.

ADJECTIVE SHIFT

INDEX = 87

A wide smooth road ended near the gate and a smooth road ended near the wide river.

The sleepy baby played under the cute table and the cute sleepy cat played under the table.

The tiny spotted puppy slept at the lake and the spotted puppy drank at the tiny lake.

INDEX = 63

A thin man stood on a strange chair and a strange thin man stood in the room.

The happy soldier waited near the tall building and the tall happy girl waited at a building.

A short thick candle burned under a lamp and a thick candle melted by the short lamp.

INDEX = 37

The funny young artist painted in the field and a young woman painted by the pretty fence.

The yellow truck arrived at the long garage and a new yellow truck parked on the street.

A green bug hopped in the warm grass and the old green car drove on the grass.

INDEX = 13

The small sad boy rested under the tree and a brown horse rested in a big yard.

A bright red ball bounced on the lawn and the pink ball stopped by a little stick.

The round bottle fell near the empty chair and a long straight arrow broke by a chair.

ADJECTIVE, VERB, PREPOSITIONAL SHIFT

INDEX = 87

A wide smooth road ended near the gate and near the wide river a smooth road ended.

Under the cute table the sleepy baby played and the cute sleepy cat played under the table.

The tiny spotted puppy slept at the lake and at the tiny lake the spotted puppy drank.

INDEX = 63

On a strange chair a thin man stood and a strange thin man stood in the room.

Near the tall building the happy soldier waited and the tall happy girl waited at a building.

A short thick candle burned under a lamp and by the short lamp a thick candle melted.

INDEX = 37

The funny young artist painted in the field and by the pretty fence a young woman painted.

At the long garage the yellow truck arrived and a new yellow truck parked on the street.

In the warm grass a green bug hopped and the old green car drove on the grass.

INDEX = 13

The small sad boy rested under the tree and in a big yard a brown horse rested.

A bright red ball bounced on the lawn and by a little stick the pink ball stopped.

Near the empty chair the round bottle fell and a long straight arrow broke by a chair.

APPENDIX C

Sample Rating Booklet of the Type Used in Experiment III

Is American English your native language? YES NO (Circle one)

Do you speak any language other than
American English fluently? YES NO (Circle one)

We are interested in some of the linguistic properties of sentences. As proficient speakers of English, you are going to be asked to give us some linguistic judgments of sentences.

On the following four pages, you will find some sentences and rating scales. Read each sentence carefully. When you finish reading each one, circle the number below it which best represents your linguistic judgment of the sentence.

A sentence is acceptable if a speaker of English would use it in normal speaking or writing.

Work quickly but carefully. Do not omit any sentences. Circle only one number for each scale. For example:

unacceptable 1 2 3 4 5 6 7 acceptable

Remember, use the scale given beneath each sentence and circle the one number which best represents your linguistic judgment of the sentence.

Near the empty chair the round bottle fell and a long straight arrow broke.

unacceptable 1 2 3 4 5 6 7 acceptable

There is a ripe apple which is cold and juicy.

unacceptable 1 2 3 4 5 6 7 acceptable

A short thick candle burned under a lamp and a thick candle melted by the short lamp.

unacceptable 1 2 3 4 5 6 7 acceptable

The rabbit moved quietly and the bear walked softly.

unacceptable 1 2 3 4 5 6 7 acceptable

A wide smooth road ended near the gate and a wide smooth road ended near the river.

unacceptable 1 2 3 4 5 6 7 acceptable

The yellow truck arrived at the long garage and a new yellow truck parked on the street.

unacceptable 1 2 3 4 5 6 7 acceptable

There is an empty stove that is wide and flat.

unacceptable 1 2 3 4 5 6 7 acceptable

A bright red ball bounced on the lawn and the little pink ball stopped by a stick.

unacceptable 1 2 3 4 5 6 7 acceptable

The bird sang loudly and the dog barked softly.

unacceptable 1 2 3 4 5 6 7 acceptable

Under the cute table the sleepy baby played and the cute sleepy cat played under the table.

unacceptable 1 2 3 4 5 6 7 acceptable

There is a small cow that is brown and white.

unacceptable 1 2 3 4 5 6 7 acceptable

The small sad boy rested under the tree and a brown horse rested in a big yard.

unacceptable 1 2 3 4 5 6 7 acceptable

Near the tall building the happy soldier waited and the tall happy girl waited at a building.

unacceptable 1 2 3 4 5 6 7 acceptable

The cook laughed happily but the soldier talked nicely.

unacceptable 1 2 3 4 5 6 7 acceptable

A warm green bug hopped in the grass and the old green car drove on the grass.

unacceptable 1 2 3 4 5 6 7 acceptable

There is a tiny mouse who is funny and cute.

unacceptable 1 2 3 4 5 6 7 acceptable

The tiny spotted puppy slept at the lake and the spotted puppy drank at the tiny lake.

unacceptable 1 2 3 4 5 6 7 acceptable

The funny young artist painted in the field and by the pretty fence a young woman painted.

unacceptable 1 2 3 4 5 6 7 acceptable

The train moved rapidly but the car drove quickly.

unacceptable 1 2 3 4 5 6 7 acceptable

A strange thin man stood on a chair and a strange thin man stood in the room.

unacceptable 1 2 3 4 5 6 7 acceptable

APPENDIX D

Digit, Letter and Word Strings Used in Experiments IV and V

Digit strings, List 1, repetitions in same orders.

<u>INDEX = 80</u>

1 4 7 5 0 and 2 4 7 5 0

7 0 2 9 3 and 7 0 2 1 3

9 7 4 6 8 and 9 7 4 6 1

<u>INDEX = 60</u>

9 4 2 3 0 and 5 8 2 3 0

3 1 7 5 9 and 3 1 8 0 9

4 3 7 8 2 and 4 3 6 8 0

<u>INDEX = 40</u>

8 9 2 1 4 and 0 5 6 1 4

2 8 7 3 6 and 2 1 5 0 6

9 2 4 1 0 and 9 8 5 1 7

<u>INDEX = 20</u>

7 4 3 9 2 and 7 0 5 1 8

3 0 8 6 5 and 1 7 9 4 5

2 5 9 3 8 and 6 1 7 3 0

Digit strings, List 1, repetitions in different orders.

INDEX = 80

1 4 7 5 0 and 4 5 0 7 2

7 0 2 9 3 and 2 3 0 1 7

9 7 4 6 8 and 6 4 7 1 9

INDEX = 60

9 4 2 3 0 and 0 8 3 5 2

3 1 7 5 9 and 9 0 8 1 3

4 3 7 8 2 and 6 4 8 3 0

INDEX = 40

8 9 2 1 4 and 4 6 5 0 1

2 8 7 3 6 and 5 6 1 0 2

9 2 4 1 0 and 7 1 8 5 9

INDEX = 20

7 4 3 9 2 and 8 0 7 5 1

3 0 8 6 5 and 9 4 5 7 1

2 5 9 3 8 and 3 0 7 1 6

Digit strings, List 2, repetitions in same orders.

INDEX = 80

2 5 8 6 1 and 3 5 8 6 1

8 1 3 0 4 and 8 1 3 2 4

0 8 5 7 9 and 0 8 5 7 2

INDEX = 60

5 0 3 4 1 and 6 9 3 4 1

4 2 8 6 0 and 4 2 9 1 0

5 4 8 9 3 and 5 4 7 9 1

INDEX = 40

9 0 3 2 5 and 1 6 7 2 5

3 9 8 4 7 and 3 2 6 1 7

0 3 5 2 1 and 0 9 6 2 8

INDEX = 20

8 5 4 0 3 and 8 1 6 2 9

4 1 9 7 6 and 2 8 0 5 6

3 6 0 4 9 and 7 2 8 4 1

Digit strings, List 2, repetitions in different orders.

INDEX = 80

2 5 8 6 1 and 5 6 1 8 3

8 1 3 0 4 and 3 4 1 2 8

0 8 5 7 9 and 7 5 8 2 0

INDEX = 60

5 0 3 4 1 and 1 9 4 6 3

4 2 8 6 0 and 0 1 9 2 4

5 4 8 9 3 and 7 5 9 4 1

INDEX = 40

9 0 3 2 5 and 5 7 6 1 2

3 9 8 4 7 and 6 7 2 1 3

0 3 5 2 1 and 8 2 9 6 0

INDEX = 20

8 5 4 0 3 and 9 1 8 6 2

4 1 9 7 6 and 0 5 6 8 2

3 6 0 4 9 and 4 1 8 2 7

Letter strings, List 1, repetitions in same orders.

INDEX = 80

P W O G E and D W O G E

I U S F V and I U S N V

H L B A M and H L B A J

INDEX = 60

H V A D I and B Q A D I

G M F C Z and G M W R Z

X L E N P and X L T N J

INDEX = 40

C I L W S and G N Z W S

K P H Q M and K E I O M

A D X R Y and A F V R B

INDEX = 20

E H W T M and E O I S X

X G R L B and N A Y Q B

C J P Z V and D U K Z F

Letter strings, List 1, repetitions in different orders.

INDEX = 80

P W O G E and E D G O W

I U S F V and U N V I S

H L B A M and B J L H A

INDEX = 60

H V A D I and Q D B I A

G M F C Z and M Z R G W

X L E N P and N J L X T

INDEX = 40

C I L W S and S N W G Z

K P H Q M and O I M E K

A D X R Y and R V B A F

INDEX = 20

E H W T M and I O E X S

X G R L B and Y B Q A N

C J P Z V and K U Z F D

Letter strings, List 2, repetitions in same orders.

INDEX = 80

O V N F D and C V N F D

H T R E U and H T R M U

G K A Z L and G K A Z I

INDEX = 60

G U Z C H and A P Z C H

F L E B Y and F L V Q Y

W K D M O and W K F M I

INDEX = 40

B H K V R and F L Y V R

J O G P L and J D H N L

Z C W Q X and Z E U Q A

INDEX = 20

D G V S L and D N H R W

W F Q K A and M Z X P A

B I O Y U and C T J Y E

Letter strings, List 2, repetitions in different orders.

INDEX = 80

O V N F D and D C F N V

H T R E U and T M U H R

G K A Z L and A I K G Z

INDEX = 60

G U Z C H and P C A H Z

F L E B Y and L Y Q F V

W K D M O and M I K W F

INDEX = 40

B H K V R and R M V F Y

J O G P L and N H L D J

Z C W Q X and Q U A Z E

INDEX = 20

D G V S L and H N D W R

W F Q K A and X A P Z M

B I O Y U and J T Y E C

Word strings, List 1, repetitions in same orders.

INDEX = 80

thin shouted silly girl the and thin shouted silly man the

a bloomed fresh flower red and the bloomed fresh flower red

bottle the purple empty bounced and bottle the purple empty rolled

INDEX = 60

small a broke table round and small a tipped table new

yellow large stopped truck the and yellow plain stopped car the

silver fast the landed plane and a fast dark landed plane

INDEX = 40

knife straight fell the sharp and knife crooked thin the slipped

green thick the shook tree and a brown big shook tree

jumped playful kitten tiny a and jumped deer young surprised a

INDEX = 20

toy a little cute broke and blue round plate the broke

square heavy arrived package a and fell bright the package orange

the green hopped bug small and the old flew owl noisy

Word strings, List 1, repetitions in different orders.

INDEX = 80

shouted girl thin silly the and man the silly shouted thin

flower red bloomed fresh a and fresh bloomed flower the red

bottle purple bounced empty the and purple rolled bottle the empty

INDEX = 60

small broke table round a and tipped new small a table

large stopped truck the yellow and yellow the stopped plain car

plane silver landed fast the and fast landed plane a dark

INDEX = 40

straight fell knife the sharp and crooked the slipped knife thin

tree green shook thick the and big shook tree a brown

jumped playful tiny a kitten and young a jumped deer surprised

INDEX = 20

toy cute a broke little and plate the broke round blue

arrived package a square heavy and orange the fell package bright

bug green hopped the small and noisy flew owl old the

Word strings, List 2, repetitions in same orders.

<u>INDEX = 80</u>

silly the shouted girl thin and silly the shouted man thin

a red bloomed flower fresh and the red bloomed flower fresh

empty the bottle purple bounced and empty the bottle purple rolled

<u>INDEX = 60</u>

table small broke a round and table small tipped a new

stopped large the truck yellow and stopped plain the car yellow

silver landed the plane fast and dark landed a plane fast

<u>INDEX = 40</u>

the straight fell knife sharp and the crooked slipped knife thin

thick the green shook tree and brown a big shook tree

jumped kitten playful tiny a and jumped surprised deer young a

<u>INDEX = 20</u>

cute a toy little broke and plate round blue the broke

arrived square a package heavy and orange the fell package bright

the small hopped bug green and the flew noisy owl old

Word strings, List 2, repetitions in different orders.

INDEX = 80

thin the girl silly shouted and man the shouted thin silly

a bloomed red flower fresh and red the flower fresh bloomed

empty bounced bottle purple the and purple rolled empty the bottle

INDEX = 60

round broke table a small and a tipped small table new

yellow large the stopped truck and plain the car yellow stopped

the landed fast plane silver and plane fast dark landed a

INDEX = 40

sharp fell straight knife the and the slipped knife crooked thin

tree thick the shook green and brown a shook tree big

kitten playful jumped tiny a and a jumped deer young surprised

INDEX = 20

broke cute little a toy and the broke round plate blue

heavy a arrived package square and bright fell orange the package

green small hopped bug the and owl the flew old noisy

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